NASA Science Mission Directorate
Earth Science Division
Applied Sciences Program

Near Real-time Volcanic Cloud Products for Aviation Alerts

Disasters

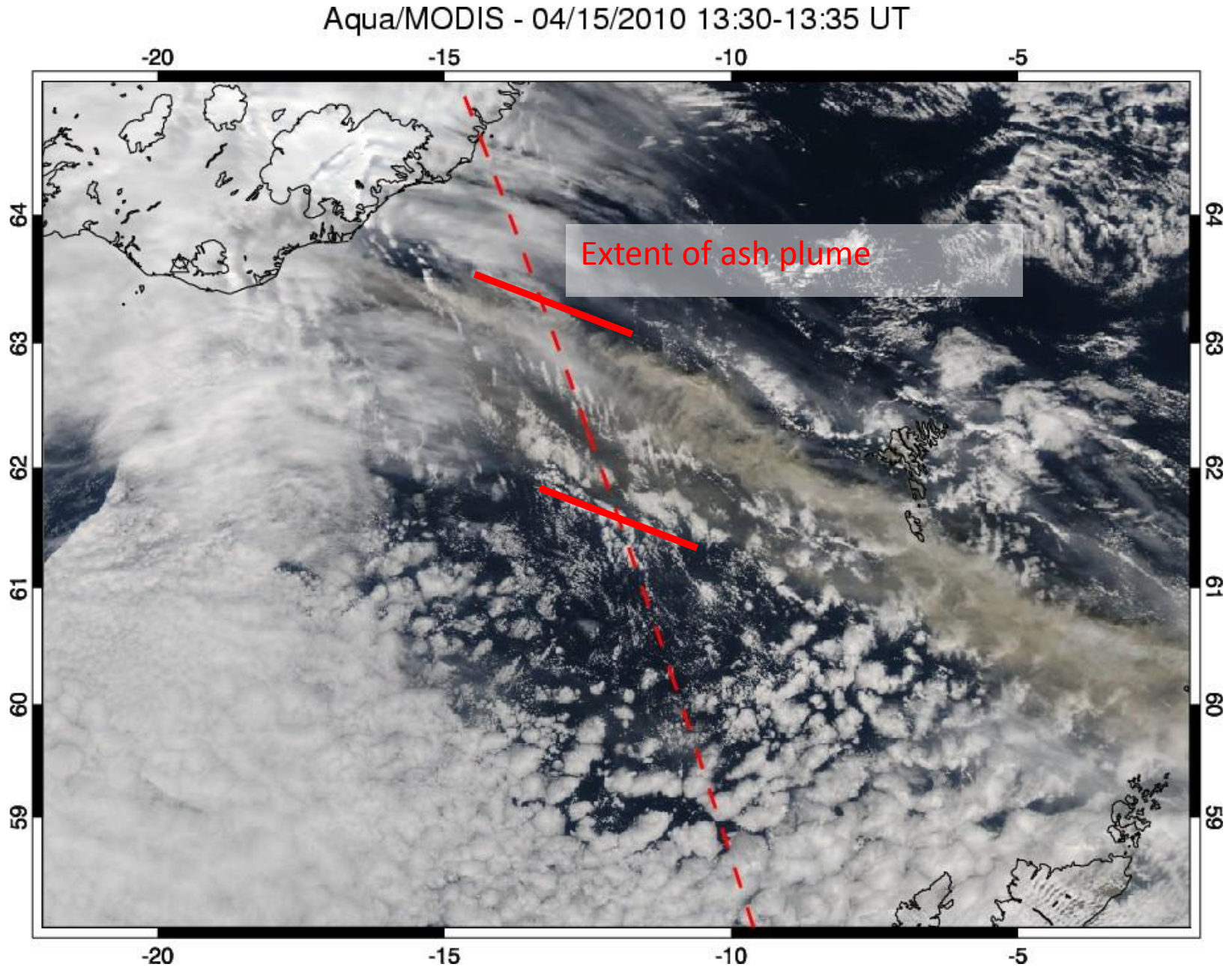
Tunisia CRTN Visit to GSFC May 29 2013

Near Real-time Volcanic Cloud Products for Aviation Alerts

- PI: Nickolay Krotkov (NASA/GSFC), Co-Is: Shahid Habib, Arlindo da Silva (NASA/GSFC), Kai Yang, Eric Hughes (AOSC/UMCP), Keith Evans (JCET/UMBC)
- Solicitation: ROSES11 A33, Disasters
- Project Summary: Continuing collaboration with NOAA and other partner organizations (AVO/USGS) to utilize and disseminate NASA volcanic SO_2 and ash data to improve the DSS for aviation early warning.
- Aura/OMI products to be enhanced using operational S-NPP/JPSS sensors and direct readout at ground stations in Finland and Alaska.
- If selected for phase II, project will provide improved medium range forecasts of volcanic cloud location and vertical distribution from NASA GEOS-5 model.
- Earth observations applied: Aura Ozone Monitoring Instrument (OMI); Suomi – NPP Ozone Mapping and Profiling Suite (OMPS), AIRS

- Disaster Cycle: Alerts/Mitigation/Post Disaster Assessment

April 15 Eyjafjallajökull eruption plume – Aqua/MODIS



The A-Train

Aura (2004-)

OMI - SO_2, NO_2, BrO

TES - SO_2

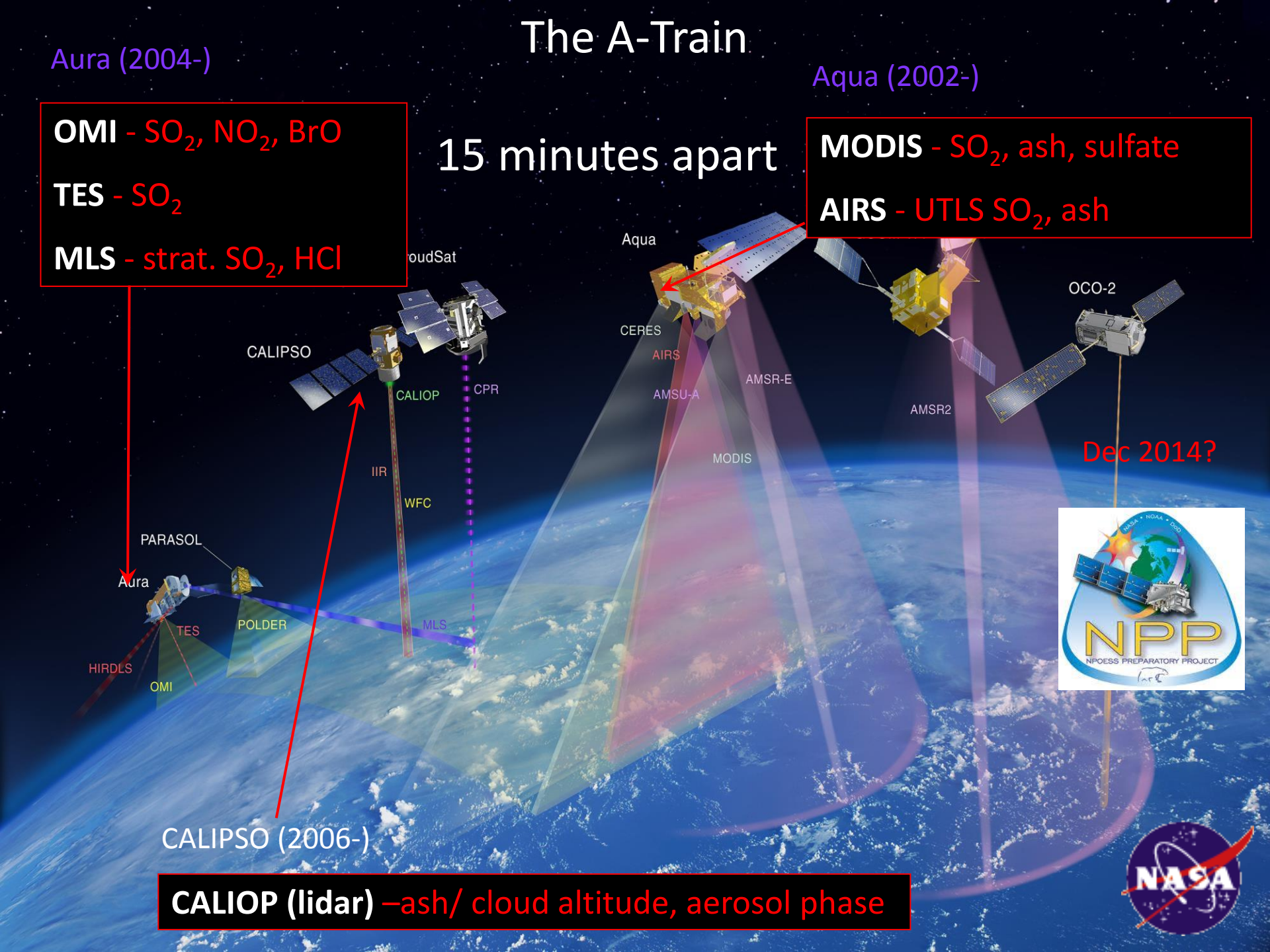
MLS - strat. SO_2, HCl

15 minutes apart

Aqua (2002-)

MODIS - SO_2, ash, sulfate

AIRS - UTLS SO_2, ash



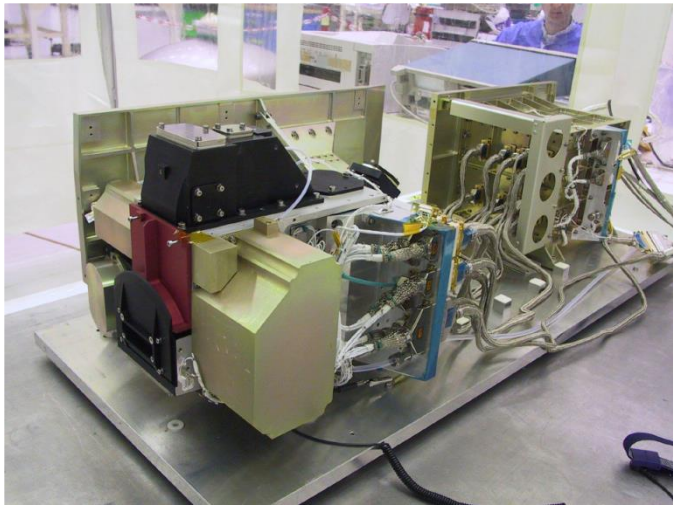
Dec 2014?

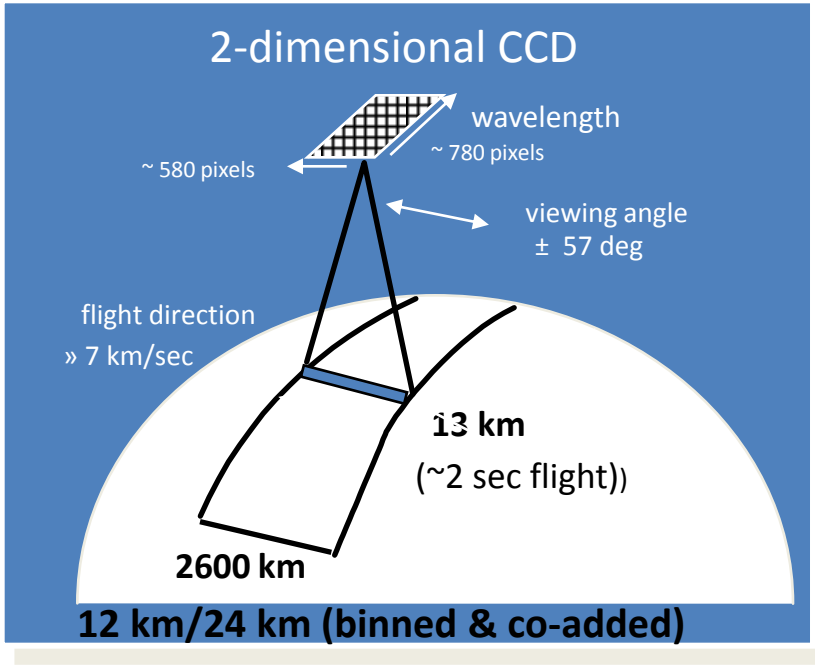
CALIPSO (2006-)

CALIOP (lidar) –ash/ cloud altitude, aerosol phase

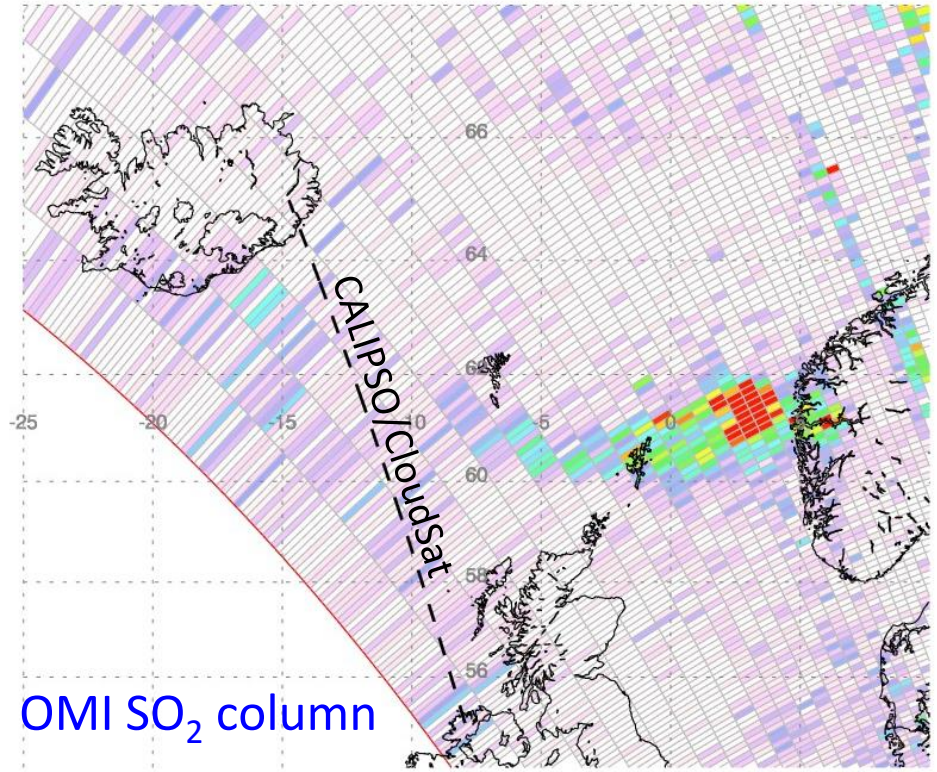
Aura / Ozone Monitoring Instrument (OMI) continues 30+ year O_3 and SO_2 records

- Launched on NASA EOS Aura platform in 2004,
- Joint Dutch-Finnish Instrument with Duch/Finish/U.S. Science Team
  - PI: P. Levelt, KNMI
  - Hyperspectral wide FOV Radiometer
    - 270-500 nm
    - 13x24 km nadir footprint (highest UV resolution from space !)
    - Swath width 2600 km (contiguous coverage)
  - Radicals: Column O_3, NO_2, BrO, OClO
  - O_3 profile ~ 5-10 km vert resolution
  - Tracers: Column **SO_2** , HCHO
  - Aerosols (**Volcanic Ash**, smoke, dust)
  - Cloud top press., cloud coverage
  - Surface UVB
  - Tropospheric ozone

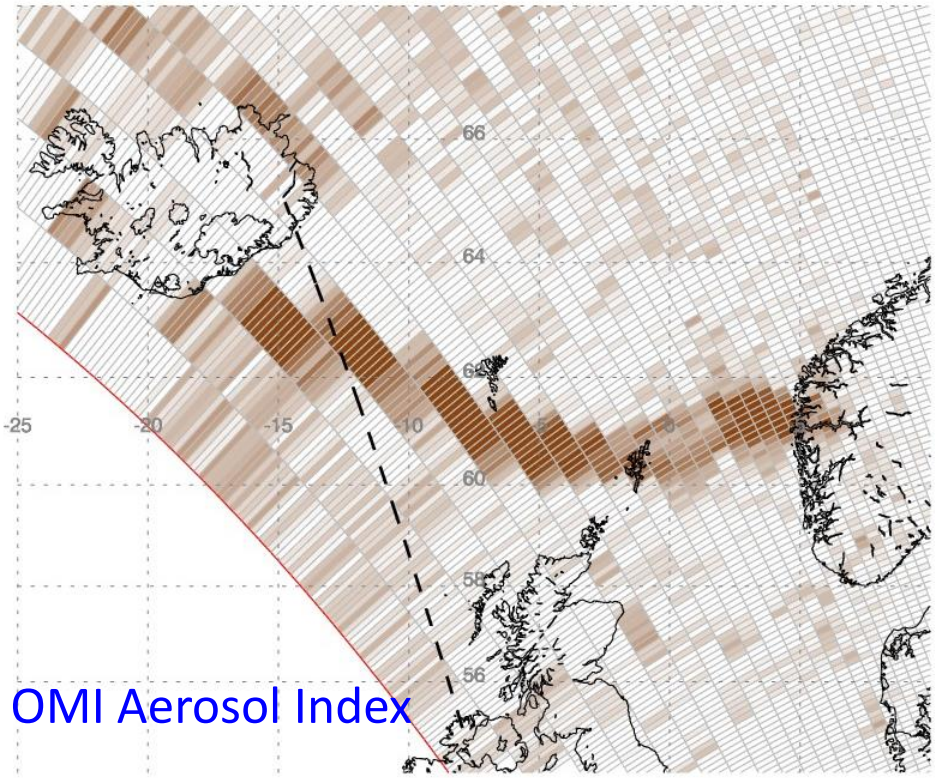




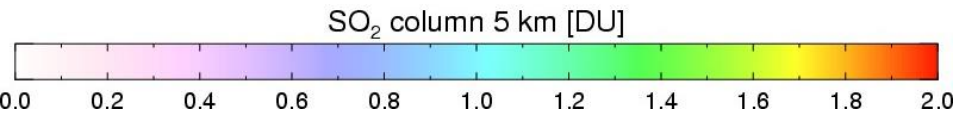
OMI view of Eyjafjallajökull eruption plume on April 15, 2010

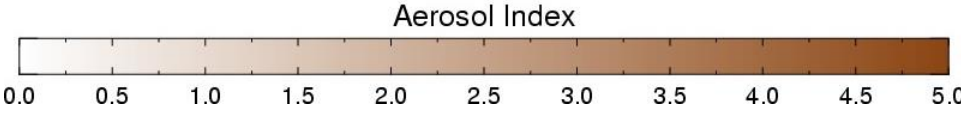


OMI SO_2 column



OMI Aerosol Index





- Near real-time (NRT) OMI SO_2 and AI data produced within 3 hours of satellite overpass and displayed at NOAA operational site:
- (http://satepsanone.nesdis.noaa.gov/pub/OMI/OMISO2/index.html)

NASA VOLCANIC CLOUD DATA FOR AVIATION HAZARDS

The Eyjafjallajokull Eruption of 2010

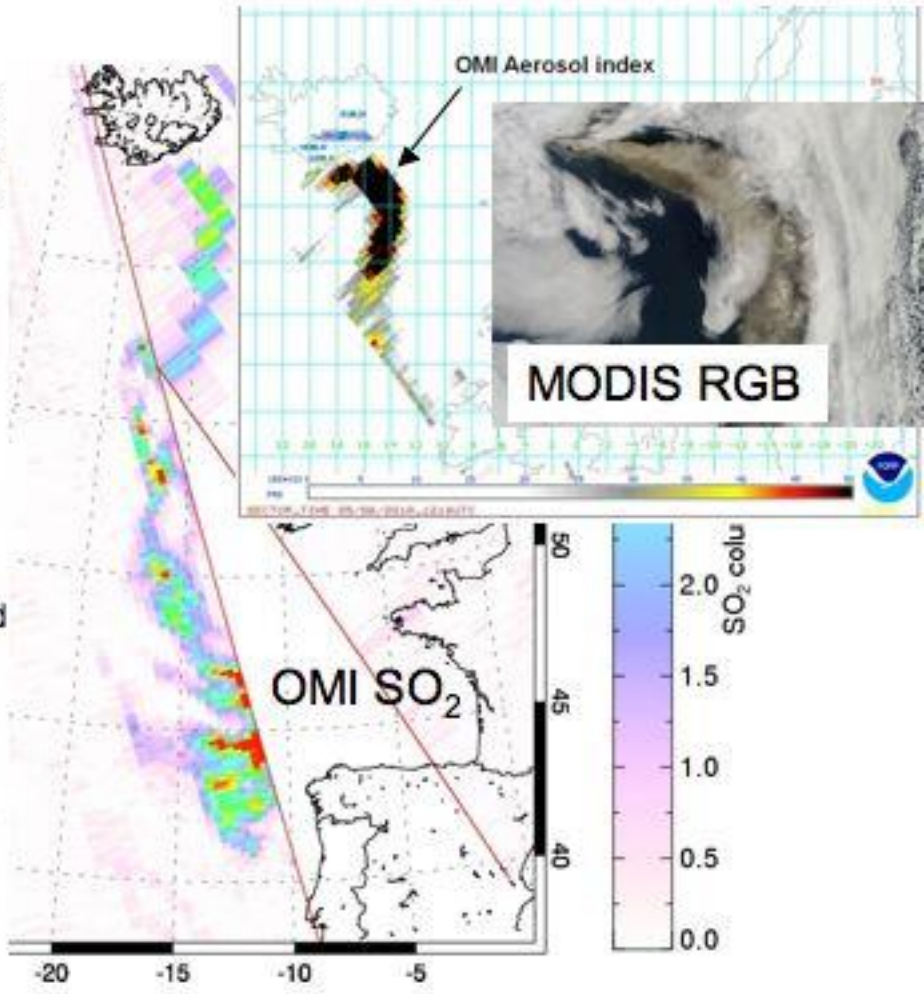
Background

- NASA has demonstrated reliable and more accurate detection of volcanic ash clouds using NASA Aura/OMI SO2 data. The proven utility of this data led to its operational use at the Volcanic Ash Advisory Centers (VAAC's) in the NOAA NWS.
  - NOAA VAAC website provides direct link to the NASA products which are used operationally to formulate and validate Volcanic Ash Advisories.
  - SO_2 is a reliable marker for fresh ash clouds:
    - Clear discrimination between volcanic plume and clouds
    - SO_2 serves as clear marker of ash from explosive magmatic eruptions
    - Few large sources of SO_2 other than volcanic eruptions (smelters); however, locations of smelters and volcanoes are known and fixed (no false alarms).

Eyjafjallajokull Eruption

- NASA now provides near real-time information on volcanic SO2 and ash aerosols from Aura/OMI for the London VAAC (and other operational entities), through the NOAA VAAC website. This information had been previously available for sectors covering the Americas and the Pacific (the areas of responsibility for NOAA); however, beginning on April 19, 2010, NASA began to provide this information for sectors covering Iceland and Northwest Europe.

http://satepsanone.nesdis.noaa.gov/pub/OMI/OMISO2/index.html



Comparison of Aura/OMI SO_2 and ash plume data with Terra/MODIS visible imagery on May 6, 2010 (~1200 UTC) during the Eyjafjallajokull eruption in Iceland.

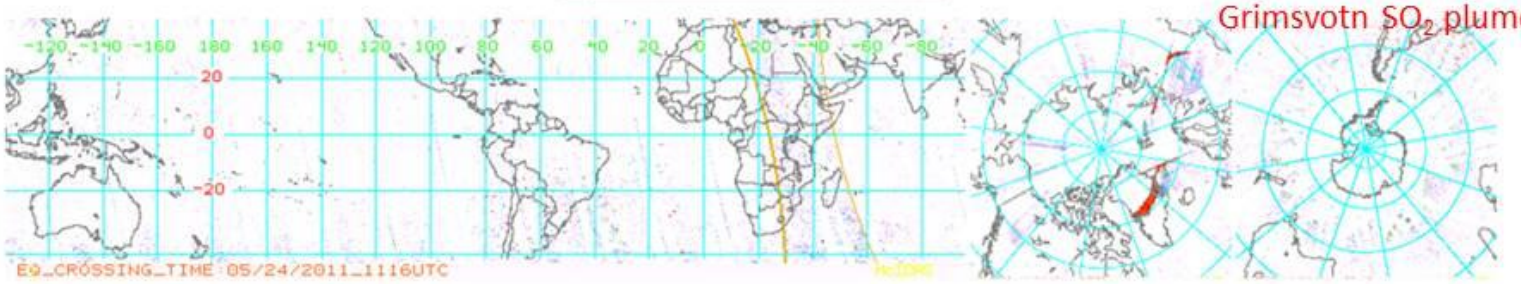
Near Real-time Volcanic Cloud Products for Aviation Alerts: NOAA operational NRT volcanic SO_2 site based on OMI SO_2 and AI data

NASA currently provides operational NRT volcanic SO_2 and AI data stream to NOAA

http://satepsanone.nesdis.noaa.gov/pub/OMI/OMISO2/index.html

Latest OMI SO2 Column 5Km - 24-Hour Composite Images

Important Information for OMI Data Users



Current OMI SO2 Composites	Tropics	Northern Hemisphere	Southern Hemisphere
Current & Previous Digital Images GeoTiff, NetCDF, McIDAS, GIF	Tropics	Northern Hemisphere	Southern Hemisphere

Latest OMI_SO2 Column 5Km by Volcano

Alaska, USA	Aleutian Islands, Alaska, USA	Anatahan, Mariana Islands	Cascade
Central America	Comoro Islands	Eastern China	Ecuador
Etna, Sicily, Italy	Galapagos Islands, Ecuador	Hawaii, USA	Iceland
Japan	Java, Indonesia	Kamchatka, Russia	Mexico
Montserrat, West Indies	New Zealand	North Western Europe	Northern Atlantic
Northern Chile	Nyiragongo, DR Congo	Peru	Philippines
Papua New Guinea	Red Sea	Reunion Island	Southern Chile
Sulawesi Sangihe, Indonesia	Sumatra, Indonesia	Tanzania	Vanuatu, South Pacific

DISCLAIM: This page is experimental and for testing purpose only

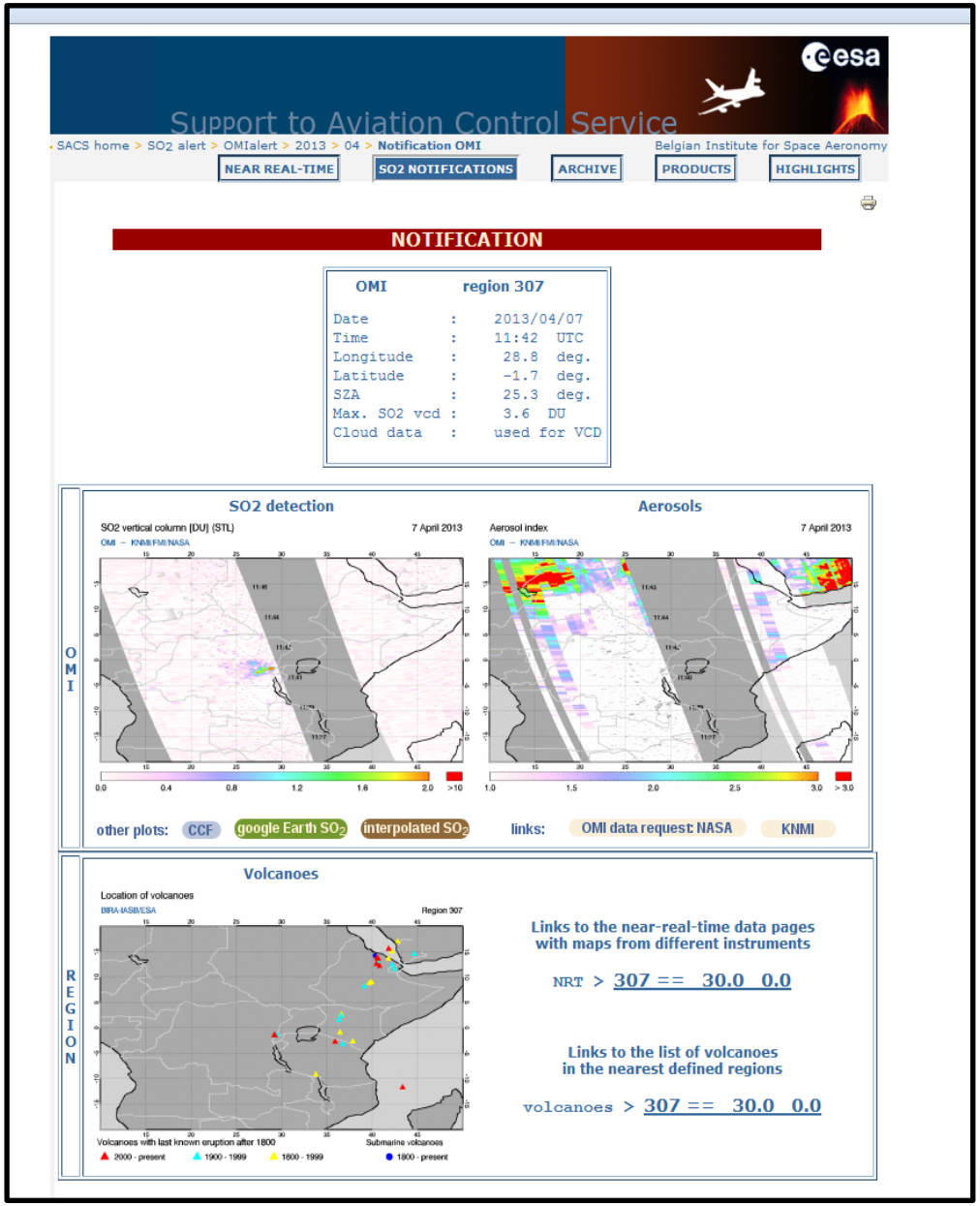
For AIRS SO2 products check the AIRS SO2 Alert Site

For science quality products check with NASA GES DISC and with the UMBC OMI Sulfur Dioxide Group

Near Real-time Volcanic Cloud Products for Aviation Alerts: Partnership with ESA/SACS

European Support for Aviation Control Service (SACS): http://sacs.aeronomie.be/nrt/

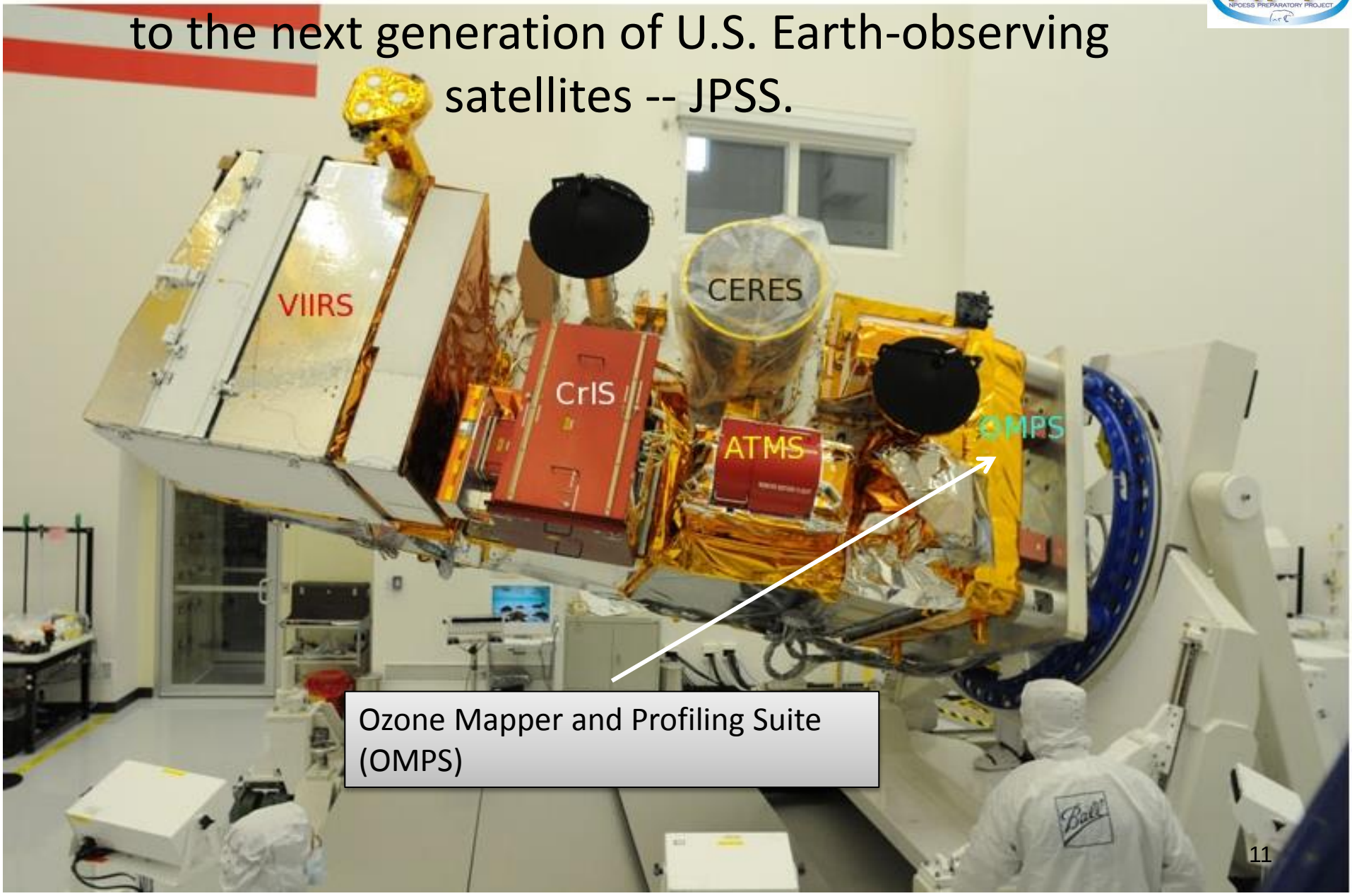
Uses NASA NRT OMI data to issue automatic e-mail volcanic alerts to more than 100 operational users



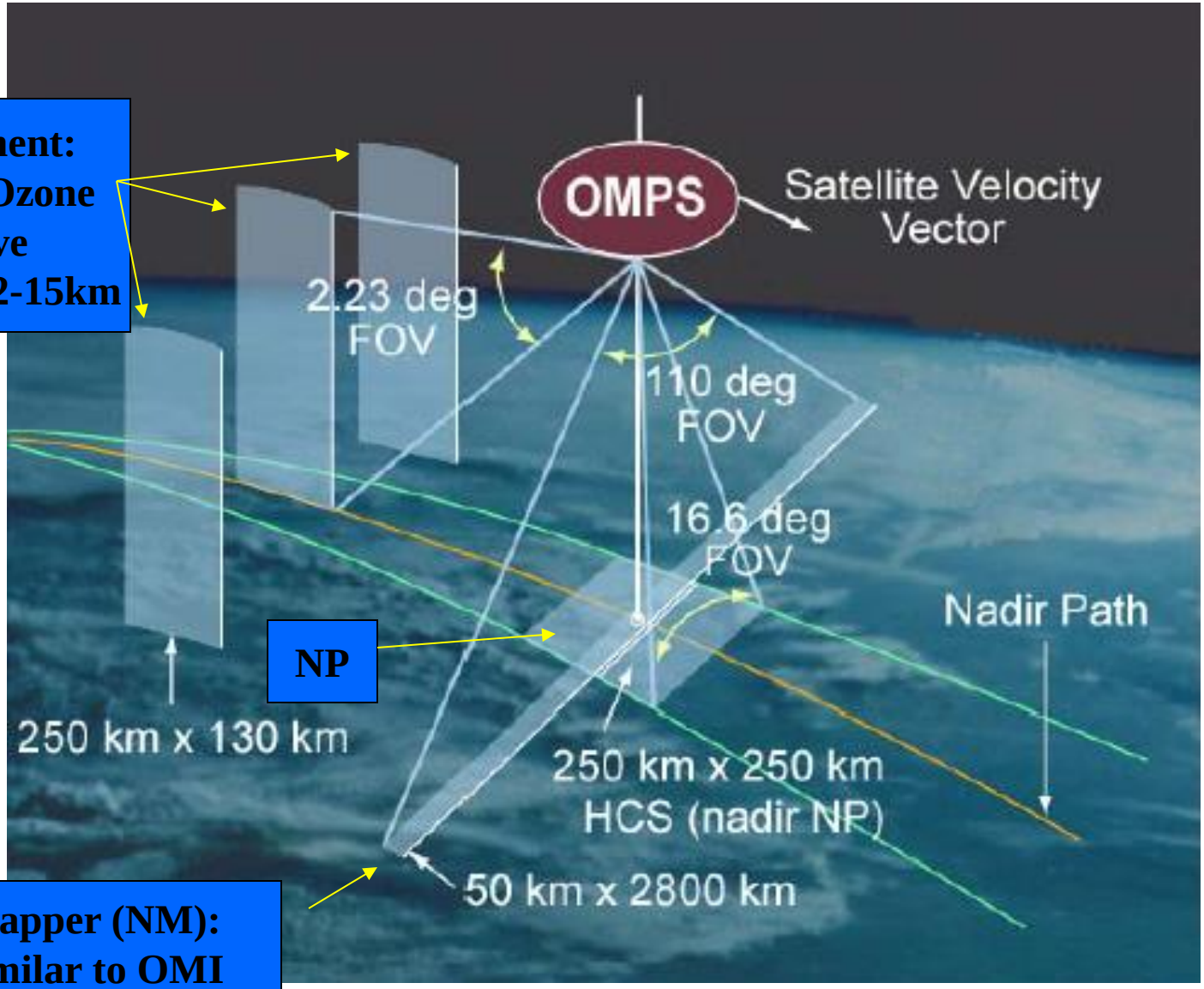
Example of the recent SACS alert based on OMI SO2 data for Nyarogongo volcano eruption on April 7 2013

NASA- NOAA Suomi- National Polar Orbiting Partnership (NPP) satellite Launched on Oct. 28, 2011 into 1:30pm ascending polar orbit

NASA-NOAA Suomi- National Polar-orbiting Partnership (NPP) satellite bridges NASA EOS to the next generation of U.S. Earth-observing satellites -- JPSS.



Suomi-NPP/OMPS UV Sensors

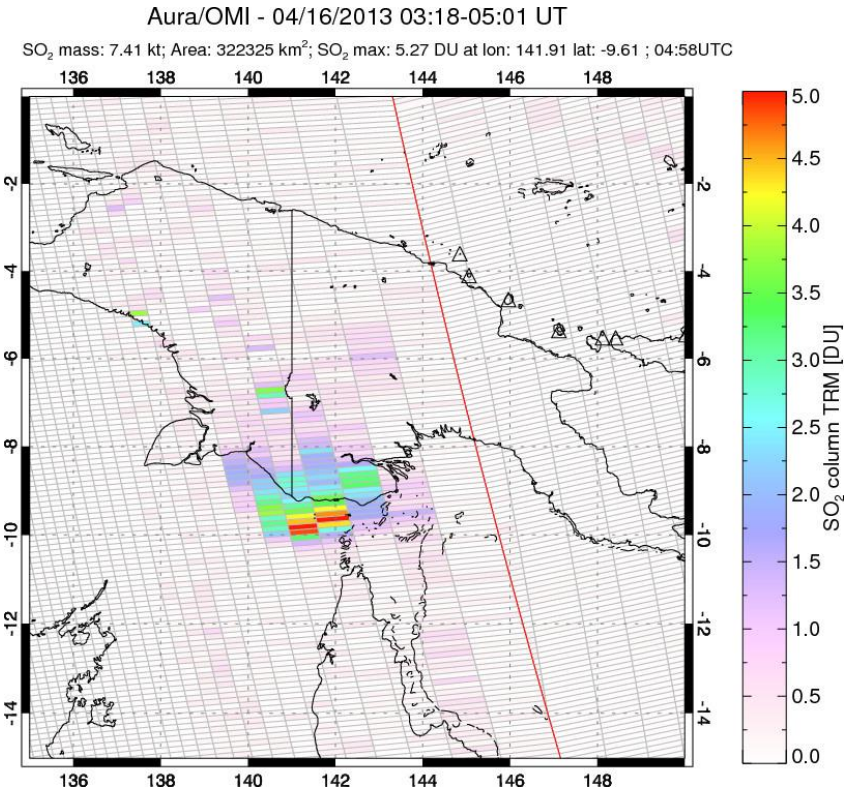


Limb instrument: Aerosol and Ozone profiles above tropopause12-15km

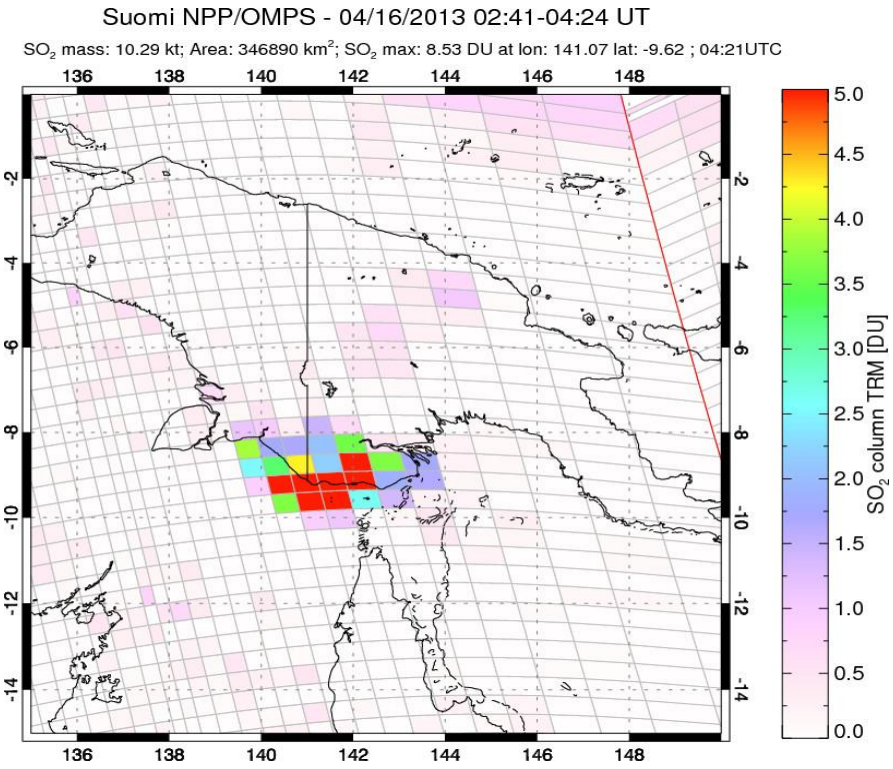
Nadir Mapper (NM): swath similar to OMI

NPP-OMPS SO2 and Aerosol Index data are in forward processing. The files (TC_EDR_SO2NRT) are on the PDR server (omisips1) under
> /pdr/NOAA/outgoing/onrts/TC_EDR_SO2NRT

Aura/OMI SO2



NPP/OMPS SO2



Near Real-time Volcanic Cloud Products for Aviation Alerts: Volcanic ash measurements by NPP/OMPS (Aerosol Index)

- NPP/OMPS volcanic Ash data currently processed at NASA

- Insert shows MODIS RGB image of the ash plume from Copahue eruption on December 2012

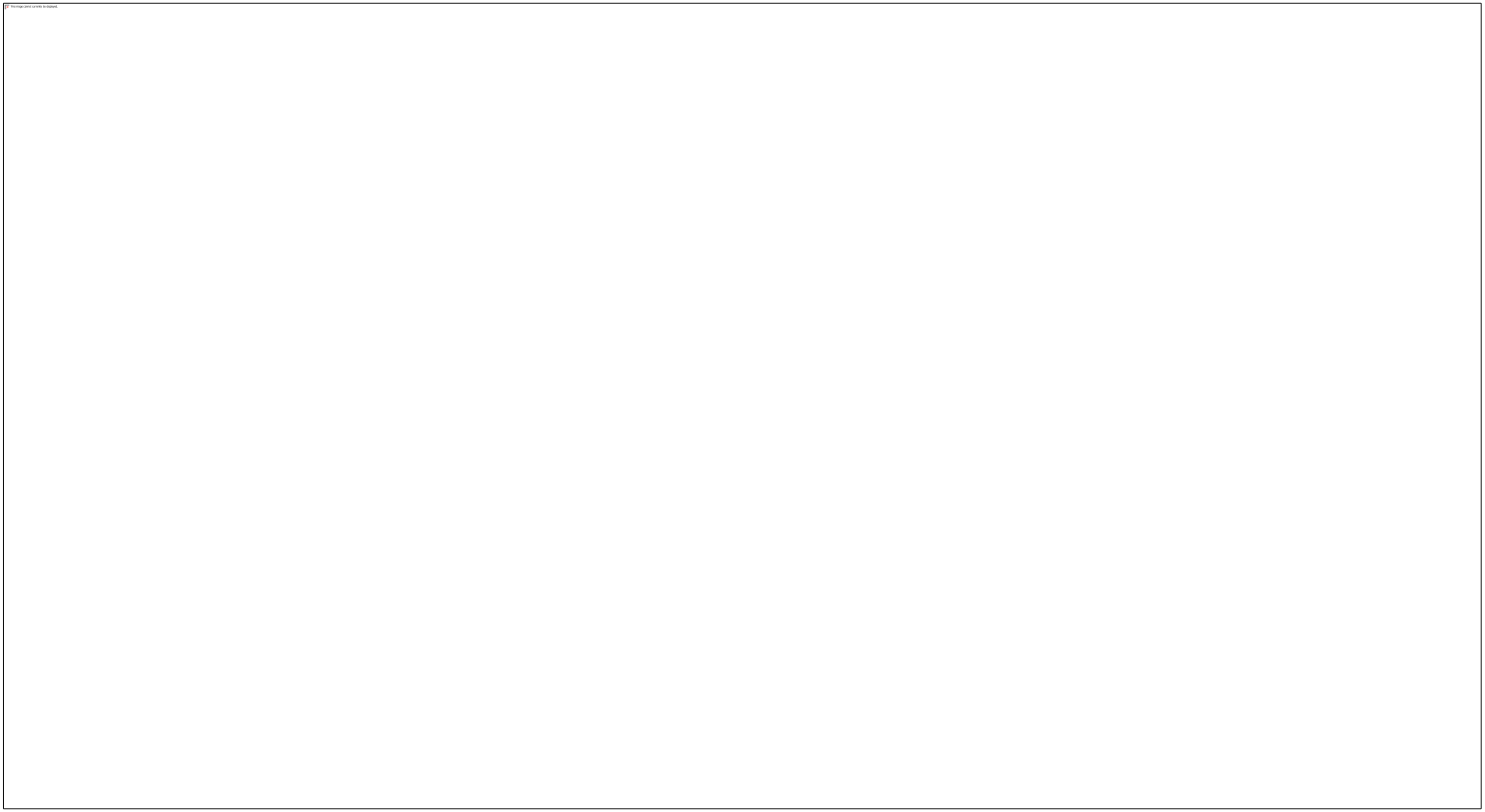
Plans: Deliver OMPS SO2 data to NOAA via ftp

- Process SO2 data at NOAA with next version of ground processing upgrade – TBA
- Process OMPS Direct Readout data locally at Goddard and in Finland and Alaska

OMPS SO_2 data – Copahue eruption (Dec 2012)

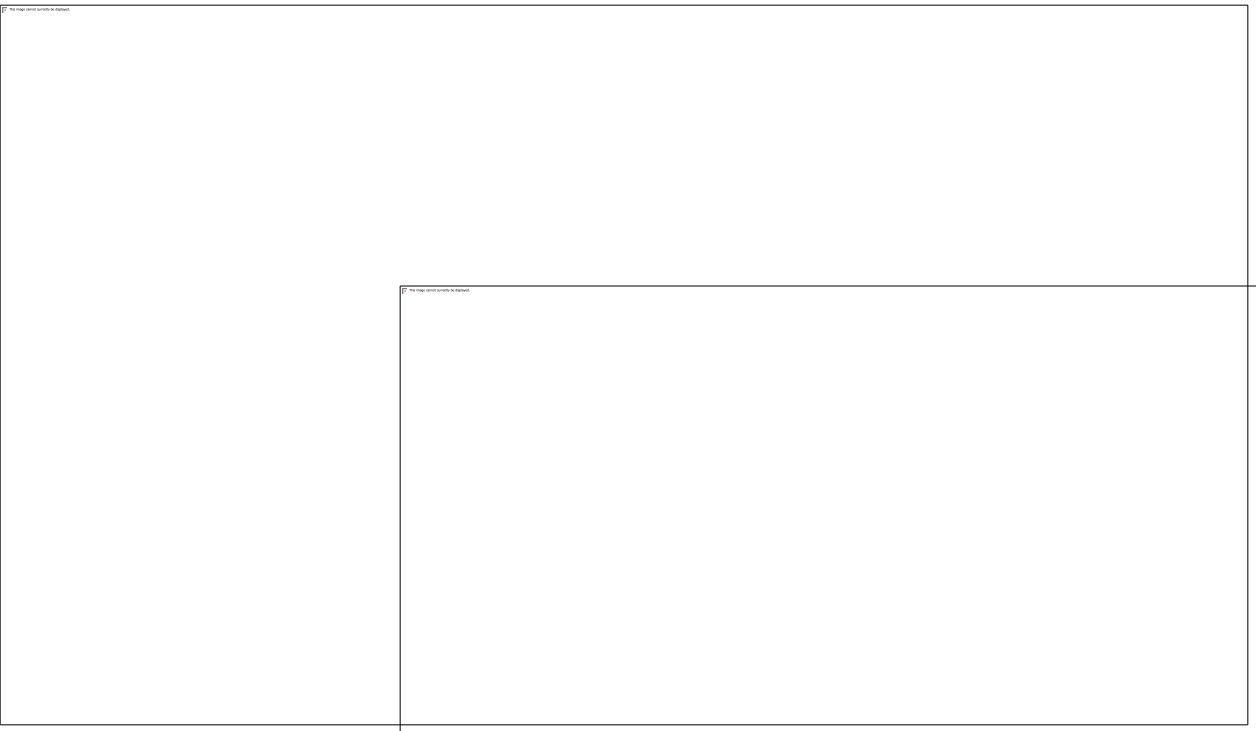
OMPS high-res SO_2 data – Copahue eruption (Dec 2012)

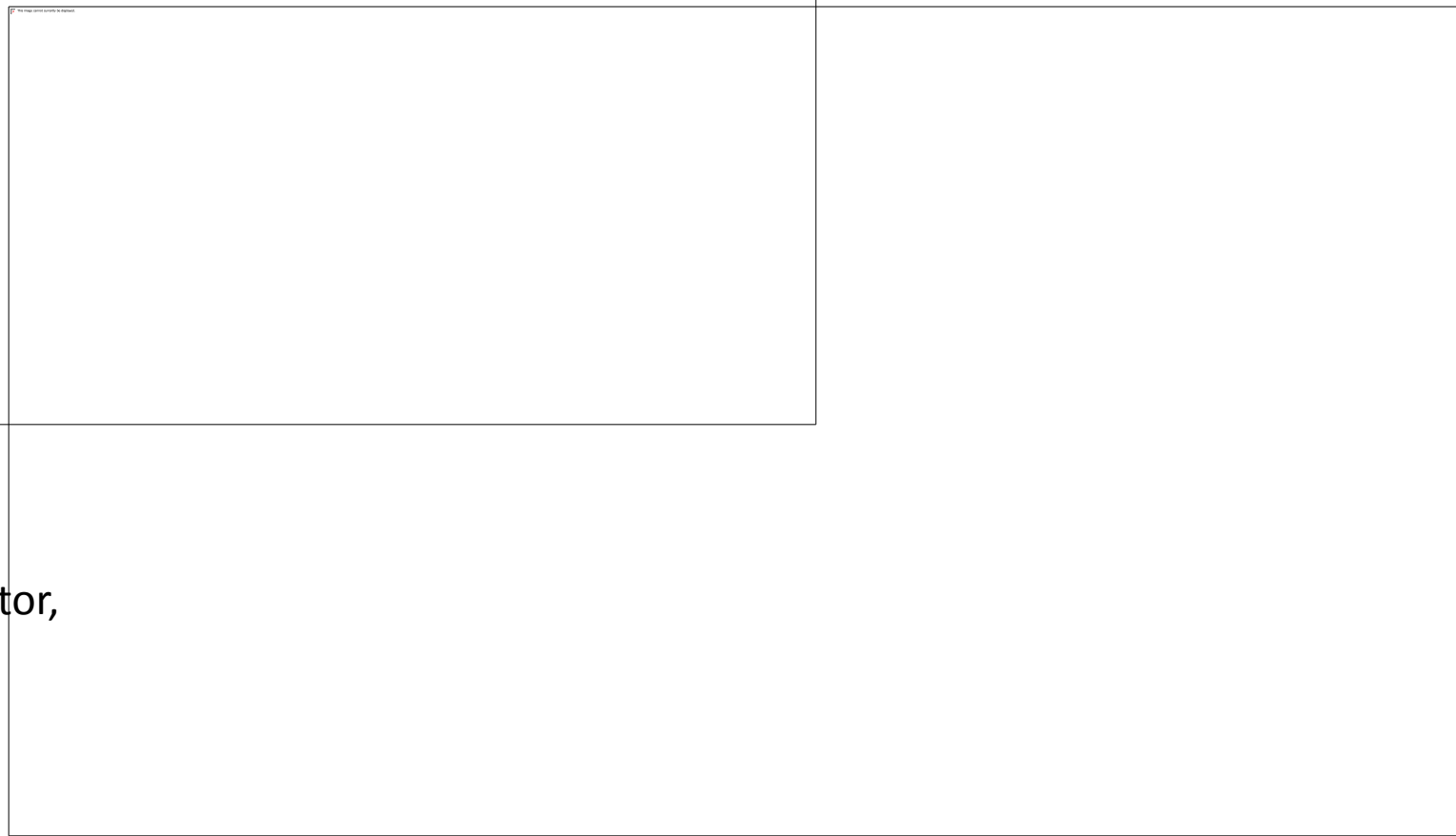
OMPS SO_2 data – Copahue eruption (Dec 2012)



OMPS SO_2 data – Copahue eruption (Dec 2012)

NPP/OMPS Aerosol Index shows dust transport





Courtesy Colin Seftor, SSAI

Direct Readout data processing at FMI and UAF/GINA

FINNISH METEOROLOGICAL INSTITUTE

UNIVERSITY OF ALASKA FAIRBANKS

Aura/OMI

Direct Broadcast from Aura and S-NPP satellites

NPP/OMPS

Receiving station in Sodankylä (FMI)

Receiving station at GINA/UAF in Fairbanks Alaska

OMI and OMPS DR processing in Sodankylä

NASA/GSFC Direct Readout Laboratory and NPP ozone PEATE create software package for local processing of NPP DR data

OMPS DR Processing at UAF/GINA

WWW and FTP services. Available within 20 min after data reception.

WWW and FTP services to Alaska Volcano Observatory. Available within 20 min after data reception.

http://omivfd.fmi.fi

First Arctic DR maps composites from Sodankylä / FMI and Alaska/GINA

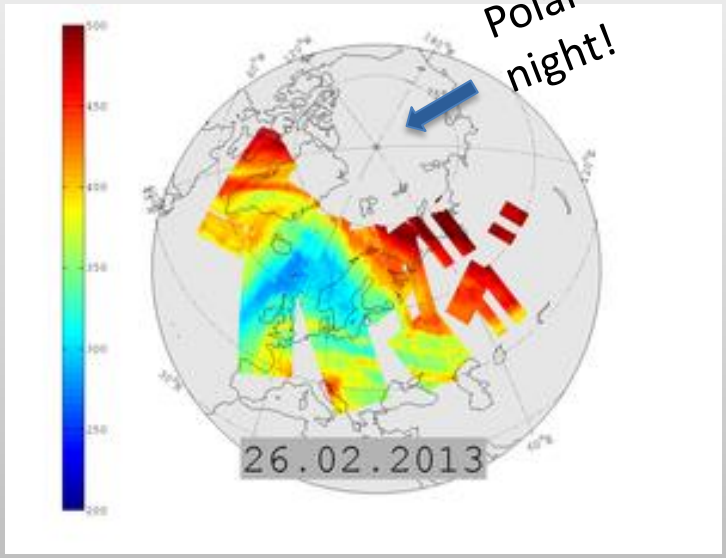


Figure on left: Sodankylä total ozone (OMDOAO3) receptions on 26th February 2013.

Figure on left: Fairbanks total ozone (OMDOAO3) receptions on 3rd April 2012.

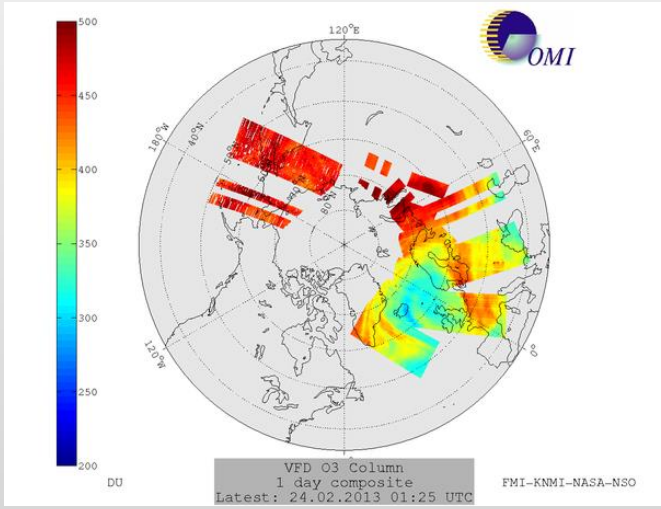
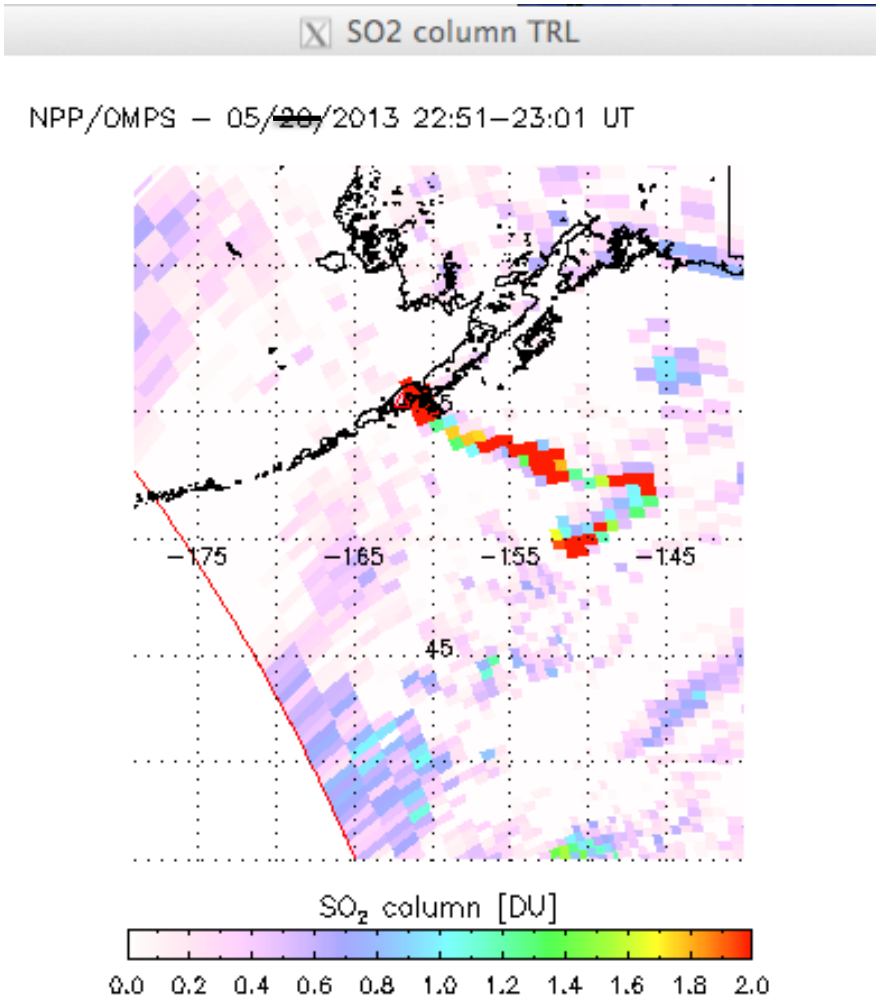
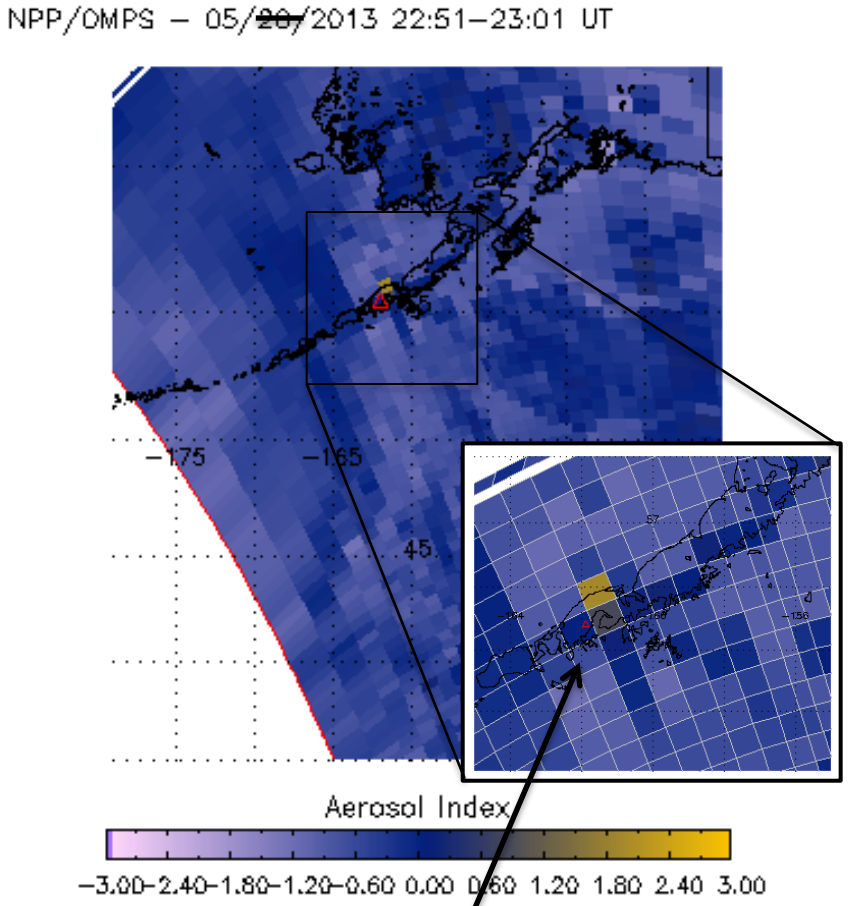


Figure on top: Sodankylä and Alaska total ozone (OMDOAO3) receptions over period of 24 hours. The last measurement was received in Fairbanks on 24th February 2013, 01:25 UTC.

S-NPP/OMPS observations of recent eruption of Pavlof volcano May 19 2013



SO_2 gas used to track volcanic air,
Large *SO_2 plume detected emitted from volcano.*



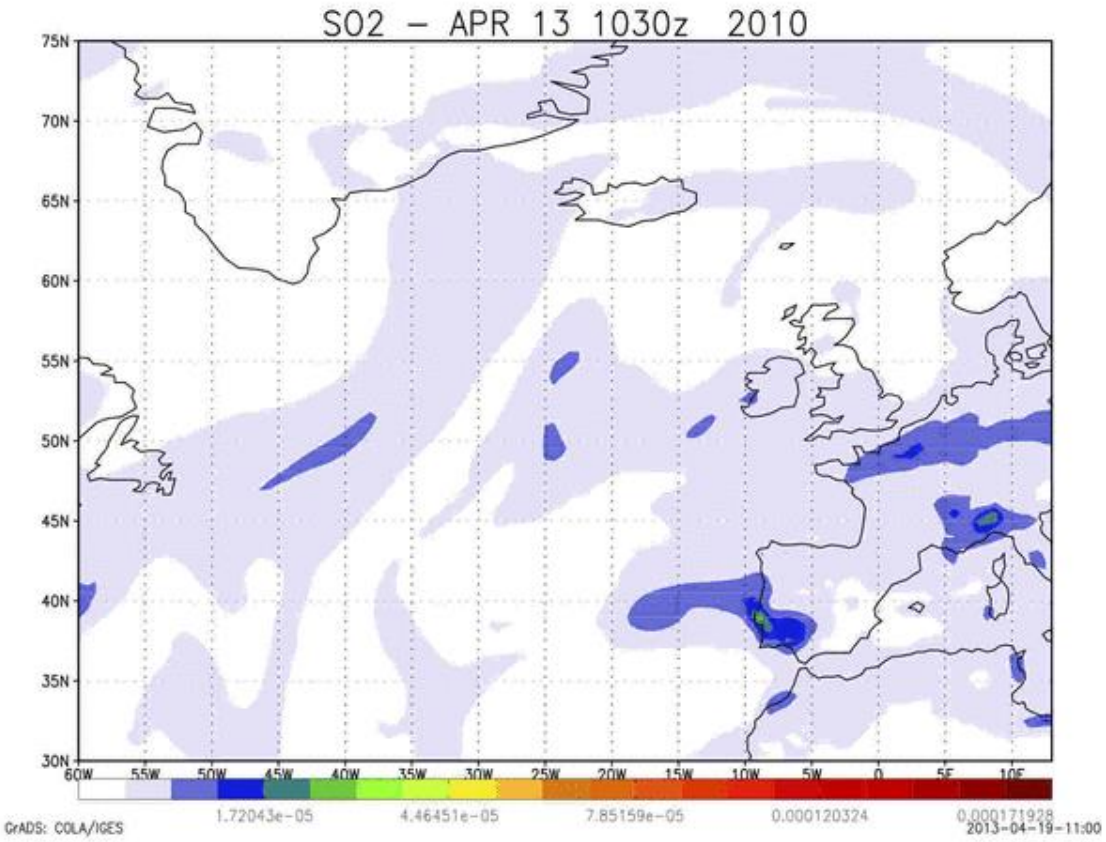
Observations indicate the presence of volcanic ash !!

Near Real-time Volcanic Cloud Products for Aviation Alerts: GEOS-5 volcanic plume forecasts

Generated Volcanic SO2 plume forecasts for Eyjafjallajokull eruption in April-May 2010 using NASA GEOS-5 global model and baseline estimates of emission flux and injection height.

Plan:

- Refine emissions using OMI SO_2 observations
- Develop satellite volcanic SO_2 assimilation technique and demonstrate improvements in forecasts
- Provide SO_2 forecasts to Metron Aviation to estimate impact on air traffic flow management
- Develop volcanic ash simulations and quantitative forecasts of ash mass concentration to determine allowable flying zones < 2 mg/m3



GEOS-5 SO2 plume forecasts for Eyjafjallajokull eruption in April-May 2010

Near Real-time Volcanic Cloud Products for Aviation Alerts: project web site

Project web site:
http://so2.gsfc.nasa.gov

- Links for latest volcanic alerts
- Links for NRT OMI and AIRS SO2 images
- Archived regional volcanic SO2 images from OMI
- Link for GEOS-5 5 day SO2 forecast from non-volcanic sources

Plans:

- Adding OMPS SO2 images and alerts
- Adding volcanic SO2 and ash forecasts